Research Proposal
Maj Howard – Vigilance Horizons Elective

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Working Title

Maestro in Space: Orchestrating Airborne Intelligence, Surveillance and Reconnaissance through Deeply Layered Sensing with Machine-to-Machine Tasking

Research Question

National space-based Intelligence, Surveillance, and Reconnaissance (ISR) assets are underutilized at the joint theater and tactical level, partly due to the relatively slow tasking cycle and inherent latency to target access, but also the lack of integration between space-based and airborne ISR tasking processes and command and control (C2) architectures. However, as more responsive and persistent[1] space-based ISR systems are deployed, their utility to the joint warfighter will increase exponentially. Therefore, it will be critical to tightly integrate the space-based and airborne ISR capabilities. Tightly integrating space and airborne ISR C2 properly will enable machine-to-machine tasking between the space and airborne layers, leading to increased effective coverage of theater ISR, increased responsiveness to time critical targeting, and opening a path to fully automated ISR capabilities (i.e. autonomous, machine-controlled sensors).[2] This research will attempt to identify disconnects in current tasking process and in various architecture modernization efforts at the National Reconnaissance Office (NRO), Air Force Space Command (AFSPC), and Air Force (AF) Distributed Common Ground Stations (DCGS) that may need to be overcome to make this crucial integration a reality as well as provide recommendations to deal with these challenges.

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Problem Background and Significance

Mr. Frank Calvelli, Principal Deputy Director of the NRO, recently told members of House Armed Services Committee the NRO can bring "capabilities to bear on a particular problem at the *speed of tasking* (emphasis added)."[3] While this statement was clearly framed for a political audience and given in an unclassified environment, one has to wonder, how fast exactly is the "speed of tasking," hours, minutes, seconds…milliseconds? And, can we do better?

Another factor driving this research is the Department of Defense's recent realization that machine learning is the next evolution in military capability. Machine learning is currently being leveraged by the Algorithmic Warfare Cross-Functional Team to "help a workforce increasingly overwhelmed by incoming data, including millions of hours of video."[4] Deputy Defense Secretary (at the time) Bob Work stated that "numerous studies have made clear, the department of defense must integrate artificial intelligence and machine learning more effectively across operations to maintain advantages over increasingly capable adversaries and competitors."[5] While teaching machine learning algorithms to pour through video streams sitting in the cloud will be a great benefit to analyst's effectiveness, the natural progression of this capability is to perform detection in real-time and tip and cue sensors automatically through machine-to-machine tasking. The central claim of this research is that machine-to-machine tasking can be leveraged to improve the "speed of tasking" and that this capability combined with the tight integration of space and airborne ISR can improve the effectiveness and responsiveness of the ISR enterprise.

Currently, the tasking of space-based ISR assets is only loosely coupled with the airborne ISR tasking. The tasking process begins when a geographic combatant commander (GCC) identifies data or information needed to meet mission objectives. This requirement is submitted to the collection management authority (CMA) who then converts intelligence or mission requirements into prioritized collection requirements. The CMA determines if a collection shortfall exists, if so, it adds the new collection requirements to one of two “collection management systems: one for satellite (national) and one for airborne (theater).”[6]. “Airborne collection systems are managed by the individual Services and tasked and coordinated at the theater level or below.”[7] Government theater and tactical airborne systems are operated and managed by the GCC through subordinate Service components. Neither the National Geospatial-Intelligence Agency (NGA) nor the National Security Agency (NSA) have CMA to task or manage airborne systems, but they may submit advisory tasking recommendations to the appropriate combatant command (CCMD).[8] On the space side, NRO field representatives are co-located with each CCMDs and serve as advisors to the GCCs and their staffs, providing support for pre-deployment training, education, weapon system integration, and dissemination of products and services.[9]

There are integration cells to act as liaisons to the services for both Signals Intelligence (SIGINT) and Geospatial Intelligence (GEOINT) tasking, but the organizational boundaries are muddied. Lt Gen Robert Otto, former Deputy Chief of Staff, ISR stated that there is a “blurred understanding of organizational roles and responsibilities, and an increasingly complex process for allocating capability in accordance with mission requirements and collection assets. Some capabilities – such as [AF] Distributed Common Ground Station (DCGS) Analysis and Reporting Teams (DARTs) and National-Tactical Integration (NTI) cells – have proved to add great value to theater intelligence, while at the same time having unclear relationships to the joint intelligence structure.”[10] This statement underscores the lack of process integration between national intelligence agencies and the Service’s theater level intelligence components.

There are architecture modernization efforts in both the space and airborne domain to leverage machine-to-machine (M2M) interfaces to speed the tasking process. The NRO is developing more agile systems, increasing to “machine-speed tasking, collection, and processing.”[11] Likewise, in 2014, the AF DCGS also “demonstrated machine-to-machine interaction” between the Common Mission Control Center (CMCC) and flying U-2 and RQ-4 aircraft.[12] While these individual pushes to machine-to-machine interfaces are encouraging, there seems to still be much work to be done to complete this modernization in both the space and airborne domains.

In a similar vein, efforts have been made to increase the interoperation of space-based and airborne assets. The NRO and Air Force have “developed a series of integrated CONOPS (Concepts of Operation)” that “describe how we will use the full spectrum of doctrine, people, weapons and policy “as part of a joint force conducting multi-domain operations…”[13] Some integration successes include Airborne Overhead Cooperative Operations (AOCO) which helps “bridge National and Tactical collection platforms to provide the warfighter with near real-time, enhanced geolocations on high-priority tactical missions. In 2015, AOCO improved geolocation accuracy by 75 percent over single sensors, and reduced specific mission planning analysis times by 90 percent.”[14]

There are a number of additional initiatives attempting to integrate ISR enterprise. Recently the Air Force concept of Global Integrated ISR (GIISR) has taken hold. GIISR is a “cross-domain synchronization and integration of the planning and operation of ISR assets; sensors; processing, exploitation and dissemination systems; and, analysis and production capabilities across the globe to enable current and future operations.”[15] GIISR employs assets from multiple commands and "leverages national capabilities in support of Service-specific requirements."[16] The key objective of GIISR is to "project global presence and battlespace awareness."[17] GIISR is also critical to compressing the "find, fix, track, target, engage, and assess (F2T2EA) process from days to minutes."[18] This research will attempt to show the relationships between all of these integration efforts and provide recommendations to fix disconnects.

The impetus for integrating space and airborne ISR is to create a deeply layered sensing framework in which sensor controllers (ideally machine-to-machine tasked) can drill up or drill down (providing increased resolution, handover due to area denial, correlate sensors inputs for better geolocation, etc.) to the appropriate sensor through a cross-cue. Layered sensing is a concept developed by the Air Force Research Laboratory (AFRL) and, in a nutshell, is an integrated array of sensors able to be accessed at anytime from anywhere. It is a "scalable system that can surveil local/theater/global-level areas of regard and rapidly focus on a specific area(s) of interest."[19] The key elements of a layered sensing architecture are persistence, wide area coverage, global access, and responsiveness. AFRL's layered sensing concept can be applied across all domains, air, space, cyberspace.[20] The vision of this researcher is a deeply layered sensing framework that effectively combines the space layer with the airborne layers coupled through machine-to-machine awareness and tasking.

A key enabler for layered sensing is what AFRL calls Universal Situational Awareness (USA). This is essentially awareness of *all* blue force sensing capabilities, as well as the status and location of those capabilities.[21] According to AFRL, "the challenges that we face to accomplish USA are more than enormous."[22] The USA concept is a key enabler of machine-to-machine tasking, since the machine must be aware of the status of the capabilities it's meant to task. If USA can only be partially implemented, that is, not universal there may be CONOPS which support limited situational awareness within a local battlespace, theater, or even a tactical element. However, the CONOPS and doctrine have yet to be established for how this virtual USA would be implemented.

Research Methodology

This research will be conducted mainly in the unclassified realm by conducting interviews with relevant organizations and referencing widely available sources. A classified annex will be used to provide further clarity on some specific topics.

Tentative Outline

- Introduction
  - Background of Problem
    - "Speed of tasking" and imperative in VUCA environment/operations
  - Thesis Statement
    - M2M offers advantages in synchronizing/integrating cross-domain capabilities
- Why is M2M tasking needed between space and airborne ISR?
  - Increased persistence in space can increase effective coverage and access of theater ISR (details in annex)
  - Fleeting targets with emission control increasingly difficult to capture manually
  - Cross-cueing between sensors of different phenomenologies
    - Different INTs
    - FMV vs still imagery
    - EO vs IR vs SAR
    - Low resolution to high resolution
  - Advantages of airborne-to-space cross-cueing (reference previous work)
  - Uses of space-to-airborne cross-cueing
  - Transitioning to fully automated ISR capabilities (autonomous, machine-controlled sensors)
    - ONR Autonomous Tactical ISR
- Background on tasking processes and C2?
  - Tasking
    - Airborne
      - CRM/COM

            - RSTA annex
            - Collection Emphasis Message
        - NTM process
        - AF space assets
    - How space assets are presented to JTF
        - C2'd/coord'd by/with GCC, JTF
    - AF-NRO CONOPS (annex)
    - C2 systems
        - CMCC
        - EGS
- Current state of integration
    - How are space and airborne ISR integrated today?
        - AOCO
        - NCCT
    - NRO integration efforts (annex)
    - Open Architecture DCGS
    - Air Force space EGS architecture
    - How are these efforts linked?
- Challenges
    - M2M integration with manual ops processes
        - Man-in-the-loop v. man-on-the-loop
    - Effectively linking architectures
    - Prioritization schema that machines understand
    - Understanding impacts to joint doctrine
        - ATO process changes
- Recommendations
    - TBD – Research will drive these
- Conclusion

Preliminary Bibliography

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[1] Additional details on persistent and responsive capabilities will be provided in Annex.
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[5] Ibid.
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[7]Ibid., IV-6
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[9] Ibid., II-4
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[20] Ibid., 21
[21] Ibid., 20
[22] Ibid.